Chapter 5 — Reinforced Concrete

Section 5-4 — Concrete Design Program (CONC)

Contents

Input Data Format (Xedit) — *continued*

Concrete Design Program
Instructions for Users

Introduction

This program is available as "CONC" on the Bridge Menu. This program will design or check reinforced concrete (RC), or Fully Prestressed Concrete (FP), or Partially Prestresed Concrete (PP) sections using the "Bridge Design Specifications" of the California Department of Transportation, hereafter referred to as the Code. The cross section may have a rectangular or flanged shape. Up to eight layers of reinforcing steel may be input and will be in either tension or compression depending on the applied loads. The bars may be input as single bars or bundled two vertically or two horizontally. The program determines the area of tension steel required to resist applied dead load and live load moments.

The program uses the STRENGTH DESIGN METHOD (Load Factor Design) based on the assumptions given in article 8.16 of the code, and on the satisfaction of the applicable conditions of equilibrium of internal stresses and compatibility of strains. At the factored level the program considers the standard HS-20 (H-FAC) and CALTRANS Permit (P-FAC) truck loadings as described in article 3.22 of the code.

The program has an option to consider loads at the service level to satisfy the serviceability requirements (Code 8.16.8) for fatigue (F-SER) and crack control (C-SER). For investigation of stresses at the service level, the straight-line theory of stress and strain is used with the assumptions as outlined in article 8.15.3 of the Code.

Input parameters include general control data, material properties, structure dimensions, rebar layout and load data. The program uses panel input (4 panels) and, where practical, parameters are defaulted to commonly used values. The program also has an XEDIT mode which allows the user to by-pass the panels and directly edit the input data file.

The program calculates the area of steel required for fatigue, crack control, factored moment (Mu), 1.2 times the cracking moment, .75 times the balanced steel ratio and prints the controlling load type. To facilitate bar cutoff calculations, the program prints the moment capacity (design moment strength) based on 100%, 80%, 60%, 40%, 20% and 0% of the area of main steel required for the controlling load type.

A table of final results containing the area of steel required for different bar sizes is also printed. The table indicates the controlling load type, maximum service stress, allowable service stress, fatigue stress range, allowable fatigue stress range, effective depth, area of steel, and rebar spacing. The program checks the bar spacing based on the code (8.21.1) and CALTRANS preferred bar spacing.

Caltrans

Input Panels

```
                         GENERAL DATA

    TITLE: ______________________________________

    (RC) REINFORCED CONCRETE
    (PP) PARTIALLY PRESTRESSED
    (FP) FULLY PRESTRESSED
    TYPE OF STRUCTURE                       (RC/PP/FP) =     __

    TYPE OF ANALYSIS                   (DESIGN OR CHECK) = ______

    CONSIDER FATIGUE?                          (YES/NO) =    ___
    CONSIDER SERVICE - CRACK CONTROL?          (YES/NO) =    ___

    ULTIMATE CONCRETE COMPRESSIVE STRESS          (FC) = ______  KSI
    ULTIMATE CONCRETE COMPRESSIVE STRAIN          (EO) = ______  IN/IN
    YOUNG'S MODULUS FOR STEEL REBARS              (ES) = ______  KSI
    YIELD STRESS FOR STEEL REBARS                 (FS) = ______  KSI

    ULTIMATE STRESS FOR PRESTRESS STEEL (270/250) (FP) = ______  KSI
    LOW-LAX PRESTRESS STEEL?                   (YES/NO) =    ___
    ENVIRONMENTAL FACTOR FOR CRACK CONTROL          (Z) =    ___  K/IN
```

```
                         STRUCTURE DATA

          TOTAL DEPTH                              = ______  FT

          TOP FLANGE EFFECTIVE WIDTH (COMP)        = ______  FT
          TOP FLANGE EFFECTIVE WIDTH (TEN)         = ______  FT
          TOP FLANGE THICKNESS                     = ______  IN

          WIDTH OF WEB                             = ______  FT

          BOTTOM FLANGE EFFECTIVE WIDTH (COMP)     = ______  FT
          BOTTOM FLANGE EFFECTIVE WIDTH (TEN)      = ______  FT
          BOTTOM FLANGE THICKNESS                  = ______  IN

                              NOTES
    1. FOR RECTANGULAR SHAPED BEAMS ENTER TOTAL DEPTH AND WIDTH OF WEB ONLY.
    2. FOR 'T' BEAMS ENTER TOTAL DEPTH, WIDTH OF WEB AND TOP OR BOTTOM FLANGE
       DATA ONLY.
    3. FOR FLANGED BEAMS THE TENSION FLANGE WIDTH DEFAULTS TO THE COMPRESSION
       FLANGE WIDTH.
```

STEEL DATA

REBAR LOC	REBAR LAYER	TOTAL BARS	BAR SIZE	COVER (IN)	BUNDLE PATTERN	SKEW ANGLE
___	___	___	___	___	___	___
___	___	___	___	___	___	___
___	___	___	___	___	___	___
___	___	___	___	___	___	___
___	___	___	___	___	___	___
___	___	___	___	___	___	___
___	___	___	___	___	___	___
___	___	___	___	___	___	___

TOTAL AREA OF PRESTRESS STEEL (AP) = _______ SQ IN

DISTANCE FROM BOTTOM OF SECTION TO C.G. OF PRESTRESS STEEL (DPS) = _______ IN

BUNDLE PATTERN:
1 = 1 BAR
2V = 2 BARS VERTICAL
2H = 2 BARS HORIZONTAL

SERVICE LOAD DATA (KIP-FT)

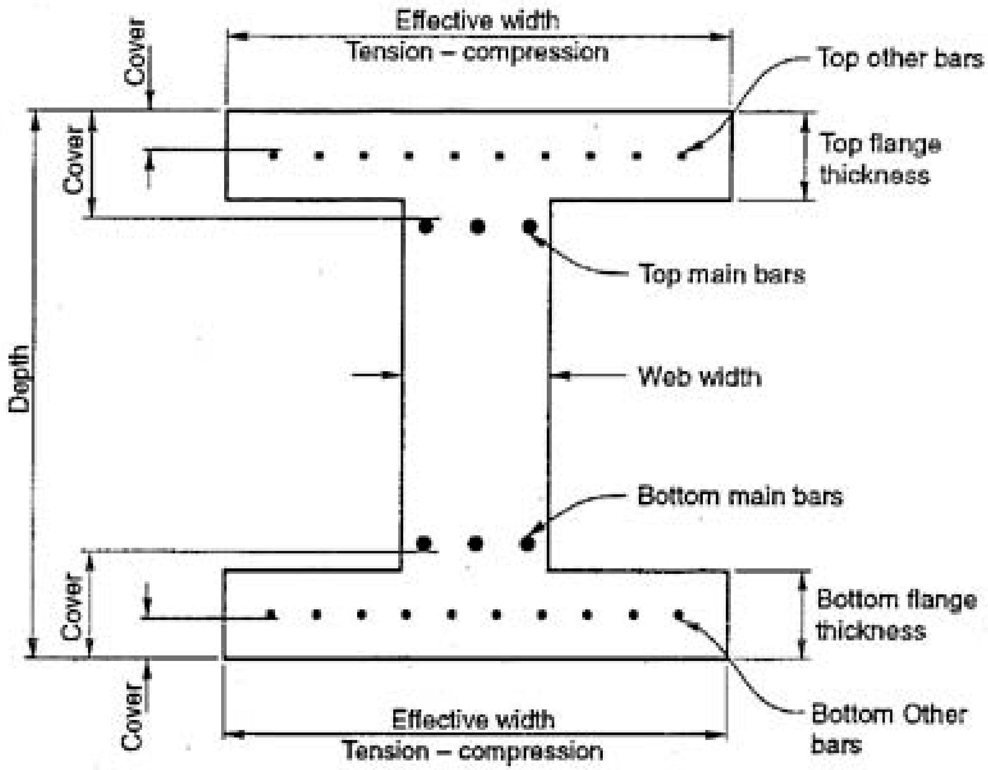
LOAD TITLE = ____

	TOTAL DEAD LOAD	MAX H-LOAD	MIN H-LOAD	MAX P-LOAD	OTHER LOAD	SECONDARY MOMENT
MOMENT	______	______	______	______	______	______
AXIAL	______	______	______	______	______	
LOAD FACTORS	____	____		____	____	____

STRENGTH REDUCTION FACTOR (PHI) = ____
FINAL PRESTRESS FORCE AFTER ALL LOSSES (PF) = _______ KIPS

NOTES
1. NEGATIVE (-) MOMENT CAUSES TENSION AT TOP OF SECTION.
2. POSITIVE (+) MOMENT CAUSES TENSION AT BOTTOM OF SECTION.
3. MINIMUM MOMENT IS USED FOR FATIGUE ANALYSIS.

General Description



Input Panel Instructions

General Data Panel

Title

Enter a maximum of 40 alphanumeric characters to identify your problem.

Type Of Structure

Reinforced Concrete (RC)

Strength design method and serviceability criteria as outlined in the code.

Fully Prestressed (FP)

Current Caltrans design specifications require zero tension in the concrete under full dead load, but allow some tension ($6 \times \sqrt{f'_c}$) under full service load. The section is still considered uncracked and is designed using gross section properties and traditional equations of mechanics.

Partially Prestressed (PP)

The trend in current design practice is to partially prestress structures by combining fully stressed tendons with mild steel reinforcement, allow $4 \times \sqrt{f'_c}$ tension in the concrete under full dead load, and allow the section to crack under full service load and satisfy ultimate strength and serviceability criteria. Partially prestressed members are designed using the same crack width and mild steel fatigue limitations as reinforced concrete. Maximum service stress in the prestress steel, after losses, is limited to 80% of yield stress. For low lax and normal, 7-strand prestressing strand, the yield stress is equal to 90% and 85% of the ultimate stress, respectively.

The allowable range between maximum and minimum tensile stress in the prestress steel caused by live load plus impact at service load, after losses, shall not exceed 22 ksi.

For more detailed information on the design of partial prestressed structures, see "A Design Procedure for Partial Prestressing of Concrete Box-Girder Bridges," by Steve McBride (SASA – 227-8268).

Type Of Analysis

Enter the type of analysis, DESIGN or CHECK. The default is DESIGN. In both the DESIGN and CHECK mode, the program computes the number of MAIN tension bars required. In CHECK mode, the designer enters the number of MAIN tension bars, the program makes a comparison to the number of MAIN tension bars computed and prints an applicable 'OK' or 'NG'.

The program prints a table of final results containing a stress analysis for crack control and fatigue requirements. In the DESIGN mode the stress analysis is based on the area of steel required for different bar sizes. In the CHECK mode the stress analysis is based on the area of steel and bar size input.

Consider Fatigue? (Code 8.16.8.3) (Yes/No)

Enter YES to consider fatigue or NO to neglect it. The program will calculate the stress range between maximum tension stress and minimum stress in the steel bars closest to the extreme tension fiber caused by live load plus impact at the service level. An area of steel is determined so that the stress range is equal to the allowable stress range. The default is YES.

Note that fatigue is checked at point of load application. The designer is responsible for assuring fatigue compliance at other sections throughout the span. Generally this is at locations where bars are terminated (cut off).

Consider Crack Control? (Code 8.16.8.4) (Yes/No)

Enter YES to consider crack control or NO to neglect it. At service level, an area of steel is determined so that the applied stress equals the allowable stress. The allowable stress depends on the number, size and spacing of the bars, the cover from the extreme tension fiber of the concrete to the center of the bar located closest to the extreme tension fiber, the area of concrete in tension having the same centroid as the bar being considered (or the C.G. of a group of bars), and the acceptable crack width (environmental Z factor). The default is YES.

Ultimate Concrete Compressive Stress

Enter the ultimate concrete compressive strength (ksi). The default is value 3.25 ksi.

Ultimate Concrete Compressive Strain

Enter the ultimate concrete compressive strain (in/in). The default value is .003 in/in.

Young's Modulus for Steel Rebars

Enter Young's modulus for the steel rebars (ksi). The default value is 29000 ksi.

Yield Stress of Steel Rebar

Enter the yield stress (ksi) of the steel rebar. The default is 60 ksi.

Ultimate Stress for Prestress Steel

Enter the ultimate stress for prestress steel. The default is 270 ksi.

Low Lax Prestress Steel

Enter yes or no. The yield stress (f'_y) for low lax strand is calculated as .90 times the ultimate stress (f'_s). For normal strand the yield stress (f'_y) is calculated as .85 times the ultimate stress (f'_s).

Environmental Factor (Code 8.16.8.4) (Z)

Enter the environmental factor Z (k/in). This is the Z factor used in the crack control check. The default is 170 k/in.

Structure Data Panel

Total Depth

Enter the total member depth (ft).

Top Flange Effective Width (Comp)

Enter the effective width of the flange when the top goes into compression. (Code 8.10)

Top Flange Effective Width (Ten)

Enter the effective width of the flange when the top goes into tension. (Code 8.17.2)

Top Flange Thickness

Enter thickness of top flange (in).

Width of Web

Enter width of web (ft.)

Bottom Flange Effective Width (Comp)

Enter the effective width of the flange when bottom goes into compression. (Code 8.10)

Bottom Flange Effective Width (Ten)

Enter the effective width of the flange when the bottom goes into tension. (Code 8.17.2)

Bottom Flange Thickness

Enter the thickness of bottom flange (in).

Notes:

Since the maximum and minimum applied moments, for the fatigue check, may be opposite in sign, the effective compression and tension flange width for both the top and the bottom of the section is required.

By providing the effective compression and tension flange width for both the top and bottom of the section, the user can design the section for positive moment on one run, then design the section for negative moment on the next run, without having to change the structure data.

For rectangular beams enter the total depth and width of web only.

For 'T-beams' enter total depth, width of web and top or bottom flange data only.

For flanged beams the tension flange width defaults to the compression flange width.

Rebar Data Panel

Rebar Location

Enter location of the rebar, TOP or BOT. TOP indicates that the rebar cover is measured from the top of the section. BOT indicates that the rebar cover is measured from the bottom of the section.

Rebar Layer

Enter the type of rebar layer, MAIN or OTHER. The designer must enter at least one MAIN tension rebar layer. MAIN indicates the rebar layer that is to be designed or checked. Only one MAIN rebar layer is allowed at the top and bottom of the section. If the applied moments are positive the area of steel for the bottom MAIN rebar layer will be determined. If the applied moments are negative the area of steel for the top MAIN rebar layer will be determined.

OTHER rebar layers are considered in the design, but their area of steel is held constant. These bars may be in either compression or tension, depending on their location and the applied moment. Up to 6 OTHER rebar layers are allowed.

Total Bars

Enter total number of bars in the layer. Since the program computes the number of MAIN tension rebars required, the number of rebars in the MAIN tension layer should be left blank in DESIGN mode. If the number of MAIN bars is entered and they go into compression they will be considered as compression steel.

In the CHECK mode the designer must enter the number of rebars in the MAIN tension layer. Always enter the total number of bars in OTHER layers.

Bar Size

Enter the Bar size.

Cover

Enter the distance from the TOP or BOT of the section to the outside of the rebar (in).

Bundle Pattern

Enter a '1' for single bars. Enter '2V' for two bars bundled in a vertical pattern. Enter '2H' for two bars bundled in a horizontal pattern.

Skew Angle

MAIN bars may not be skewed. Only OTHER bars (transverse deck reinforcement) are allowed to be skewed. The program computes an effective steel area by multiplying the actual area of the bars by the cosine of the skew angle. Note by providing both the TOP and BOT MAIN steel, the user can design the section for positive moment on one run, then design the section for negative moment on the next run, without having to change the rebar data.

Total Area Of Prestressing Steel

Enter the area of prestressing steel (sq in).

Distance From Bottom Of Section To C.G. Of Prestress Steel

Enter the distance from the bottom of section to center of gravity of the prestressing steel (in).

Service Load Data Panel

Load Title

Enter a maximum of 40 alphanumeric characters to describe the load.

Dead Load Moment (DL)

Enter the moment due to dead load (k-ft).

H-Load Moment (LL+I)

Enter the maximum and minimum moment due to standard HS-20 truck + impact loading (k-ft).

P-Load Moment (LL+I)

Enter the maximum moment due to CALTRANS Permit truck + impact loading (k-ft).

For P-Loads on closely spaced girders (PC) used only for superstructures (i.e. box girders), input the P-Load for the number of lanes loaded.

For widely spaced girders (PW) and substructures (i.e. bent cap), input the P-Load as 1.15 times one lane of 'P' load (1.15P) or input 1.15 times one lane of 'P' load plus one lane of 'H' load (1.15P + H), which ever controls.

Other Moment

Enter any other moment you want to consider. (k-ft)

Secondary Moment

Enter prestressing secondary moment. (k-ft)

Axial Loads

Enter the corresponding axial loads for DEAD LOAD, H-LOAD, P-LOAD, and OTHER LOAD. (k)

Load Factors

Enter the appropriate load factors for DEAD LOAD, H-LOAD, P-LOAD, and OTHER LOAD. The default values are 1.30, 2.17, 1.30, and 1.30 respectively.

Strength Reduction Factor

Enter strength reduction factor for bending. Default is .90 for reinforced concrete (RC), and .95 for fully prestressed (FP) and partially prestressed (PP) members.

Final Prestress Force After All Losses

Enter the final prestress force after all losses in kips.

Notes

Negative (-) moment causes tension in the top, therefore there must be a MAIN rebar layer at the top of the section.

Positive (+) moment causes tension in the bottom, therefore there must be a MAIN rebar layer at the bottom of the section.

Minimum moment is used for the fatigue analysis.

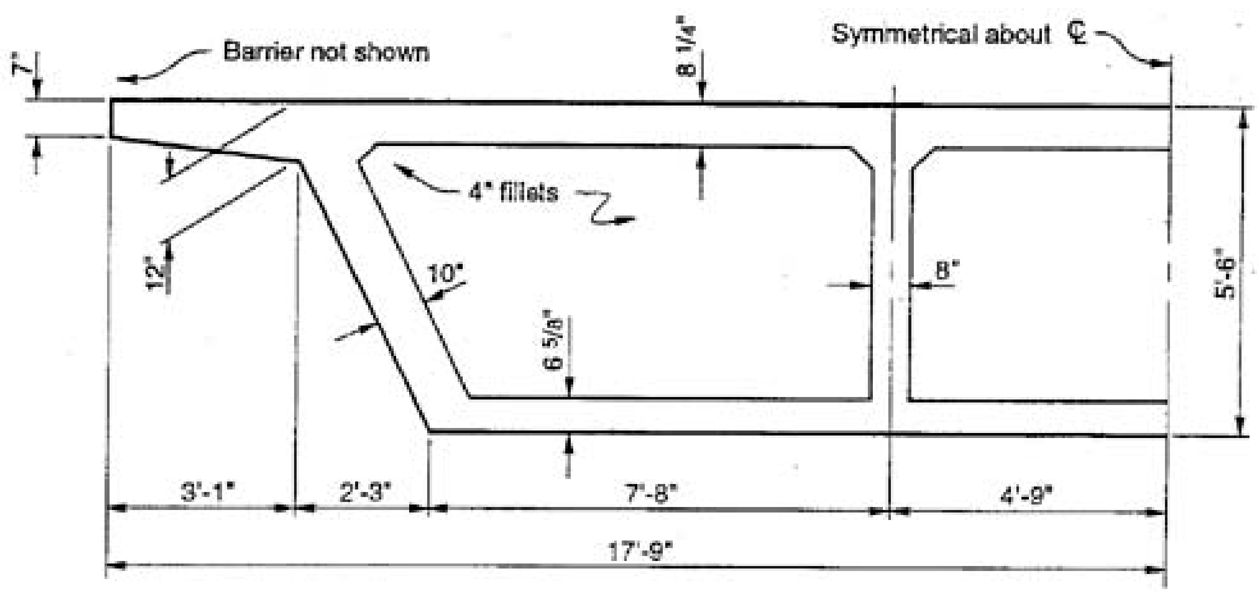
Example Problem 1

Box Girder Design

Determine the amount of tension reinforcement required in a box girder for maximum positive moment considering fatigue and crack control criteria.

Service Load Data			
	Dead Load (DL)	H - Load (LL+I)	P - Load (LL+I)
Max moment	4270	2447	4693
Min moment		-326	

1/2 – Typical Section



```
************************************
YOUR CONC FILENAME IS: BOXGDR
************************************
BOX GIRDER DESIGN                                 VERSION  2  06.01.87
      RC      DESIGN       YES        YES
    3.25       0.003     29000         60       270       YES       170
    5.50
   35.50       33.92      8.25       3.00     24.83     22.63      6.63
       1
     BOT        MAIN         0         10      2.06         1      0.00
    0.00        0.00
MAX POSITIVE MOMENT
    4270        2447      -326       4693         0         0
       0           0         0          0         0                   0
    1.30        2.17                 1.30      1.00      1.00      0.90
```

```
TITLE BOX GIRDER DESIGN                                   14:37:52  03/26/93 PAGE  1

*************************************************************************
*                                 CONC                                  *
*                        CONCRETE DESIGN PROGRAM                        *
*                        (RC) REINFORCED CONCRETE                       *
*                        (PP) PARTIALLY PRESTRESSED                     *
*                        (FP) FULLY PRESTRESSED                         *
*                 CALIFORNIA DEPARTMENT OF TRANSPORTATION               *
*                        VERSION  2     06.01.87                        *
*************************************************************************

****************
* GENERAL DATA *
*************************************************************************

TYPE OF STRUCTURE    (REINFORCED CONCRETE)  =       RC

TYPE OF ANALYSIS                            =   DESIGN

CONSIDER FATIGUE?                           =      YES
CONSIDER SERVICE - CRACK CONTROL?           =      YES

ULTIMATE CONCRETE COMPRESSIVE STRESS   (FC) =     3.25 KSI
ULTIMATE CONCRETE COMPRESSIVE STRAIN   (EO) =    0.003 IN/IN
YOUNGS MODULUS FOR CONCRETE            (EC) =    3249. KSI

YOUNGS MODULUS FOR STEEL REBARS        (ES) =   29000. KSI
YIELD STRESS FOR STEEL REBARS          (FS) =     60.0 KSI

YOUNGS MODULUS FOR PRESTRESS STEEL     (EP) =   28000. KSI
ULTIMATE STRESS FOR PRESTRESS STEEL    (FP) =    270.0 KSI
LOW-LAX PRESTRESS STEEL                     =      YES

MODULAR RATIO MILD STEEL (ES/EC)       (NS) =     8.92
MODULAR RATIO PRESTRESS STEEL (EP/EC)  (NP) =     8.62

ENVIRONMENTAL FACTOR                    (Z) =    170.0 K/IN


******************
* STRUCTURE DATA *
**************************************************************

TOTAL DEPTH                  =   5.50 FT

TOP FLANGE WIDTH (COMP)      =  35.50 FT
TOP FLANGE WIDTH (TEN)       =  33.92 FT
TOP FLANGE THICKNESS         =   8.25 IN

WIDTH OF WEB                 =   3.00 FT

BOTTOM FLANGE WIDTH (COMP)   =  24.83 FT
BOTTOM FLANGE WIDTH (TEN)    =  22.63 FT
BOTTOM FLANGE THICKNESS      =   6.63 IN
```

```
TITLE BOX GIRDER DESIGN                              14:37:52  03/26/93 PAGE  2

***************
* STEEL DATA *
***************************************************************************

REBAR  REBAR   TOTAL   BAR    COVER    BUNDLE    SKEW     EFFECTIVE
LOC    LAYER   BARS    SIZE   (INCH)   PATTERN   DEGREES  AREA
-----  -----   -----   ----   ------   -------   -------  ---------

BOT    MAIN       0     10     2.06       1       0.00      0.00

TOTAL AREA OF PRESTRESS STEEL (AP) =   0.00 SQ IN
DIST. FROM SECTION BOTTOM TO C.G. OF PRESTRESS STEEL (DP) =   0.00 IN

**********************
* LOAD DATA (KIP-FT) *
***************************************************************************

LOAD TITLE = MAX POSITIVE MOMENT

             TOTAL                                           OTHER    SECONDARY
           DEAD LOAD     H-MAX      H-MIN      P-MAX       MOMENT     MOMENT
             (DL)       (LL+I)     (LL+I)     (LL+I)      (O-MOM)    (S-MOM)
           ---------   --------   --------   --------    --------   --------

MOMENT       4270.       2447.      -326.      4693.         0.         0.
AXIAL           0.          0.         0.         0.         0.
LOAD
FACTORS      1.30        2.17                  1.30        1.00       1.00

STRENGTH REDUCTION FACTOR (PHI) = 0.90

FINAL PRESTRESS FORCE AFTER ALL LOSSES (PF) =     0.00 KIPS

****************
* DESIGN LOADS *
***************************************************************************

              MAX        MIN        MAX        MAX
             H-SER      H-SER      H-FAC      P-FAC
            -------    -------    -------    -------

MOMENT        6717.      3944.     10861.     11652.
AXIAL            0.         0.         0.         0.

LOAD COMBINATIONS:
------------------

MAX H-SER = (DL) + (H-MAX) + (O-MOM) + (S-MOM)
MIN H-SER = (DL) + (H-MIN)           + (S-MOM)

MAX H-FAC = 1.30 X (DL) + 2.17 X (H-MAX) + 1.00 X (O-MOM) + 1.00 X (S-MOM)
MAX P-FAC = 1.30 X (DL) + 1.30 X (P-MAX) + 1.00 X (O-MOM) + 1.00 X (S-MOM)
```

```
TITLE BOX GIRDER DESIGN                                14:37:52  03/26/93 PAGE  3

************************
* INTERMEDIATE RESULTS *
*********************************************************************

MAIN STEEL AREA BASED ON FOLLOWING LOAD TYPES:

S-AS  = SERVICE STRESS IN MILD STEEL (AS) (MAX H-SER)
        (CRACK CONTROL)
F-AS  = FATIGUE STRESS IN MILD STEEL (AS) (MAX & MIN H-SER)
H-FAC = H-FACTORED MOMENT
P-FAC = P-FACTORED MOMENT
MIN1  = MINIMUM REINFORCEMENT (8.17.1.1)
         BASED ON 1.2 X THE CRACKING MOMENT
MIN2  = WAIVER OF MINIMUM REINFORCEMENT (8.17.1.2)
         BASED ON STEEL AREA ONE THIRD GREATER THAN REQUIRED BY ANALYSIS.
MAX   = MAXIMUM REINFORCEMENT (8.16.3.1)
         BASED ON .75 X BALANCED STEEL RATIO.

EFFECTIVE DEPTH = 63.22 IN

YNA = DISTANCE FROM EXTREME COMPRESSIVE FIBER TO NEUTRAL AXIS.

BAR   TYPE      BAR                 APPLIED   MAIN STEEL   MAIN
SIZE  LOAD    SPACING      YNA      MOMENT    REQUIRED     BARS
                (IN)       (IN)     (K-FT)    (SQ IN)      REQ
----  -----   -------    ------    -------   ----------   ----
 10   S-AS      8.59      9.59      6717.        40.23     32
 10   F-AS      9.87                             34.39     28
 10   H-FAC     8.88      2.33     10861.        38.78     31
 10   P-FAC     8.32      2.50     11652.        41.66     33
 10   MIN1     19.03      1.07      5025.        17.79     15
 10   MIN2      6.19      3.33     15449.        55.55     44
 10   MAX       2.26      9.04     40252.       150.64    119

***** CONTROL *******************************************
 10   P-FAC     8.32      2.50     11652.        41.66     33

ULTIMATE MOMENT CAPACITY.

  TOTAL     TOTAL     OTHER      MAIN       ULT        ULT
  COMP       TEN       TEN        TEN      TENDON    MOMENT
  AREA      AREA      AREA       AREA      STRESS   CAPACITY    YNA
 (SQ IN)   (SQ IN)   (SQ IN)   (SQ IN)     (KSI)     (K-FT)     (IN)
 -------   -------   -------   -------    ------   --------   -----
   0.00     41.91      0.00     41.91       0.0     11721.     2.51
   0.00     33.53      0.00     33.53       0.0      9409.     2.01
   0.00     25.15      0.00     25.15       0.0      7081.     1.51
   0.00     16.76      0.00     16.76       0.0      4737.     1.01
   0.00      8.38      0.00      8.38       0.0      2377.     0.50
```

```
TITLE BOX GIRDER DESIGN                              14:37:52  03/26/93 PAGE  4


*******************************************
* SECTION PROPERTIES AND CONCRETE STRESSES *
***************************************************************************
(AFTER ALL LOSSES)


SECTION PROPERTES
_________________

MAIN STEEL AREA  =    41.91 IN**2

                                          UNCRACKED       CRACKED
                               GROSS     TRANSFORMED   TRANSFORMED
                             --------    -----------   -----------
AREA      (FT**2)              49.7          52.0          27.4
INERTIA   (FT**4)             223.9         244.5          57.9
YOG       (IN)                 26.5          28.1           9.8
YNA       (IN)                 26.5          28.1           9.8



CONCRETE STRESSES (PSI)
_______________________

                 UNCRACKED             UNCRACKED               CRACKED
                   GROSS              TRANSFORMED            TRANSFORMED
            :--- STRESSES ---:     :--- STRESSES ---:     :--- STRESSES ---:
LOAD TYPE     TOP       BOTTOM       TOP      BOTTOM        TOP      BOTTOM
---------   -------    -------    -------    -------     -------    -------
MIN H-SER    -270.       403.       -263.      354.        -386.        0.
MAX H-SER    -460.       686.       -447.      602.        -658.        0.

CONCRETE MODULUS OF RUPTURE                    (7.5 X SQRT FC) =   428. PSI


NOTES:

YOG = DISTANCE FROM EXTREME COMPRESSION FIBER TO CENTER OF GRAVITY.
YNA = DISTANCE FROM EXTREME COMPRESSION FIBER TO NUETRAL AXIS.
(+) = TENSION
(-) = COMPRESSION
```

```
TITLE BOX GIRDER DESIGN                                    14:37:52  03/26/93 PAGE  5


*************************
* FINAL RESULTS - DESIGN *
**************************************************************************

(AREA OF STEEL REQUIRED FOR DIFFERENT BAR SIZES)
```

		:—SERVICE—	—:	:—FATIGUE—	—:					
BAR SIZE	LOAD CONT	MAX STRESS (KSI)	ALLOW STRESS (KSI)	STRESS RANGE (KSI)	ALLOW RANGE (KSI)	EFF DEPTH (IN)	BAR SPACE (IN)	REQ STEEL (SQ IN)	TOTAL BARS REQ	SPACE CODE
18	S-AS	22.67	24.00	9.37	19.01	62.69	18.95	56.61	15	3
14	S-AS	27.26	28.12	11.26	18.12	63.06	12.66	48.48	22	
11	S-AS	30.78	31.35	12.71	17.44	63.12	9.86	43.18	28	
10	P-FAC	32.01	33.86	13.22	17.20	63.22	8.32	41.66	33	
9	P-FAC	31.90	36.00	13.17	17.22	63.31	6.50	41.60	42	
8	P-FAC	31.96	36.00	13.19	17.21	63.37	5.13	41.55	53	
7	P-FAC	31.83	36.00	13.14	17.23	63.44	3.87	41.51	70	2
6	P-FAC	31.95	36.00	13.19	17.21	63.50	2.84	41.47	95	1

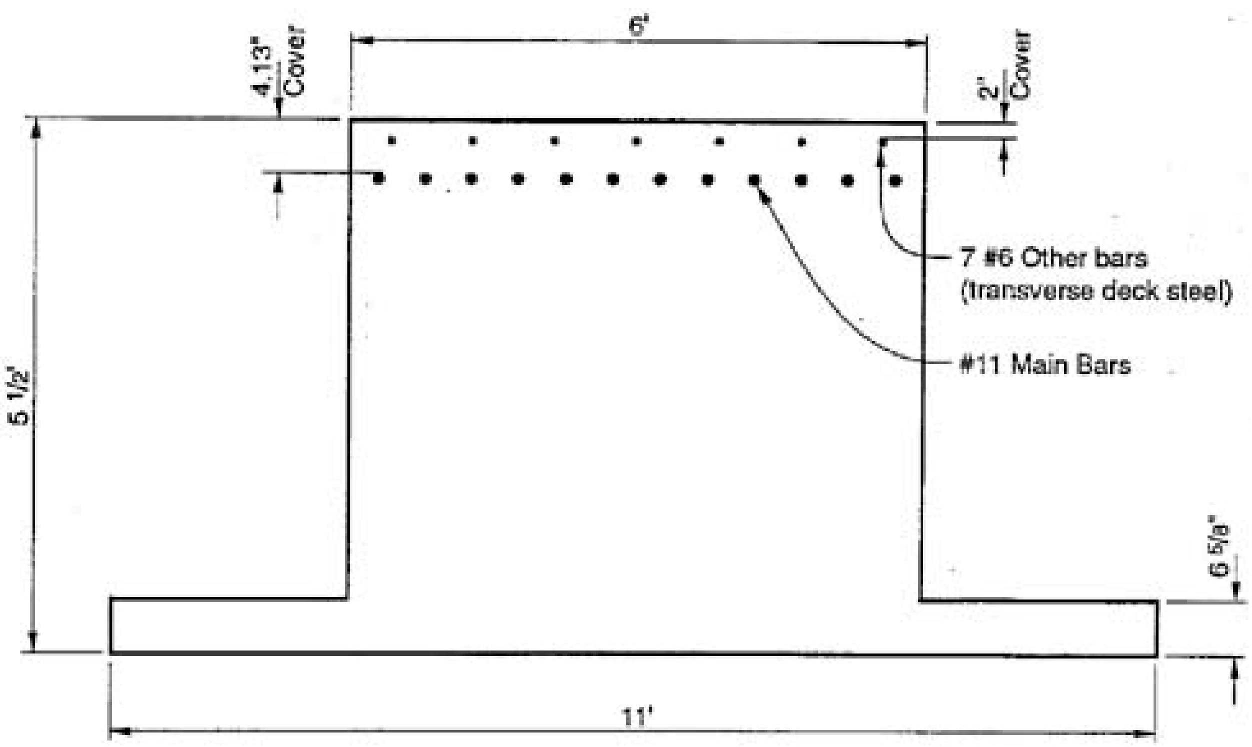
```
SPACE CODES:

1 = BAR SPACING LESS THAN THE AASHTO MINIMUM. (8.21)
2 = BAR SPACING LESS THAN THE PREFERRED CALTRANS MINIMUM. (BR. DES. DET.)
3 = BAR SPACING MORE THAN THE AASHTO MAXIMUM (18"). (8.20)
```

Example Problem 2

Bent Cap Design

Determine the amount of tension reinforcement required in a bent cap for maximum negative moment considering fatigue and crack control criteria.

Service Load Data			
	Dead Load (DL)	H - Load (LL+I)	P - Load (LL+I)
Max moment	-2146	-706	-2155
Min moment		0	



Cap-Section

Scale: 1"= 2'

```
**********************************
YOUR CONC FILENAME IS: BENTCAP
*********************************

CAP DESIGN WITH TRANSVERSE DECT STEEL      VERSION  2  06.01.87
   RC   DESIGN    YES     YES
  3.25   0.003  29000      60     270    YES    170
  5.50
 11.00    6.00   8.25    6.00   11.00   6.00   6.63
     2
   TOP    MAIN      0      11    4.13      1   0.00
   TOP   OTHER      7       6    2.00      1   0.00
  0.00    0.00

MAXIMUM NEGATIVE MOMENT
 -2146    -706      0   -2155       0
     0       0      0       0       0             0
  1.30    2.17   1.30    1.00    1.00          0.90
```